The Effect of Airborne Contaminants on Fuel Cell Performance & Durability

Richard Rocheleau
Trent Molter
William Collins
Silvia Wessel

Hawaii Natural Energy Institute at the University of Hawaii
Connecticut Global Fuel Cell Center at the University of Connecticut
UTC Power
Ballard Power Systems


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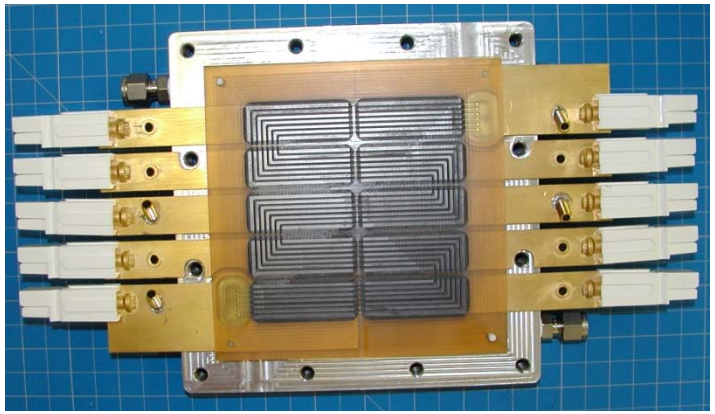
Objectives

- **Characterize effects of airborne contaminants on PEMFC performance and durability**
- **Develop understanding of and quantitative models describing contaminant effects**
- **Investigate and develop strategies to mitigate effect of air contaminants**

DOE Technical Barriers/Targets

- **Technical barriers to performance & durability:**
  - **Tolerance to air impurities not established**
  - **Development of mitigation strategies for impurities necessary**
  - **Effects of air impurities on electrochemically active area (ECA) are unknown**
  - **Loss of performance with air impurities may present challenge to meeting targets at specified catalyst loadings**
- **Technical targets for membranes & electrocatalysts:**
  - **Durability with cycling**
  - **ECA loss**
  - **Catalyst support loss**
  - **Mass and specific activity loss**

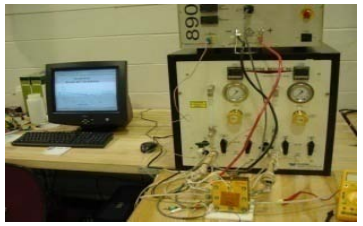
Hawaii Fuel Cell Test Facility

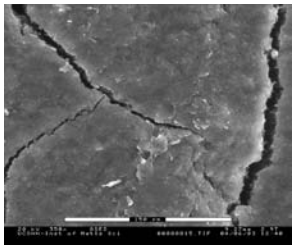


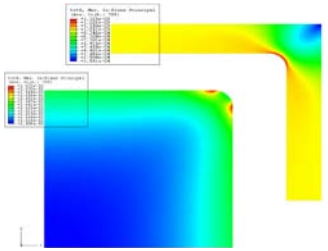
- Eleven test stations including single cell, stack, and HIL testing capabilities (up to 2kW)
- High resolution on-line gas analysis with sub-ppm detection limits
- Demonstrated closure of steady state molar flow balance for fuel impurities to 1ppm level
- Multiple segmented cell testing systems with simultaneous electrochemical characterization of all segments over wide range of current density
- Effluent water collection with ion selective electrode for measurement of S and Fl ions
- Spatial gas sampling from flow channels under development
- Ongoing work with NREL and ONR to characterize effect of fuel and air contaminants
- Laboratory for MEA and cell fabrication
- Access to UH surface analysis laboratories including: Pacific Biological Electron Microscope Facility & Department of Oceanography
- Modelica modeling for analysis of spatial contaminant effects in cell

Connecticut Global Fuel Cell Center

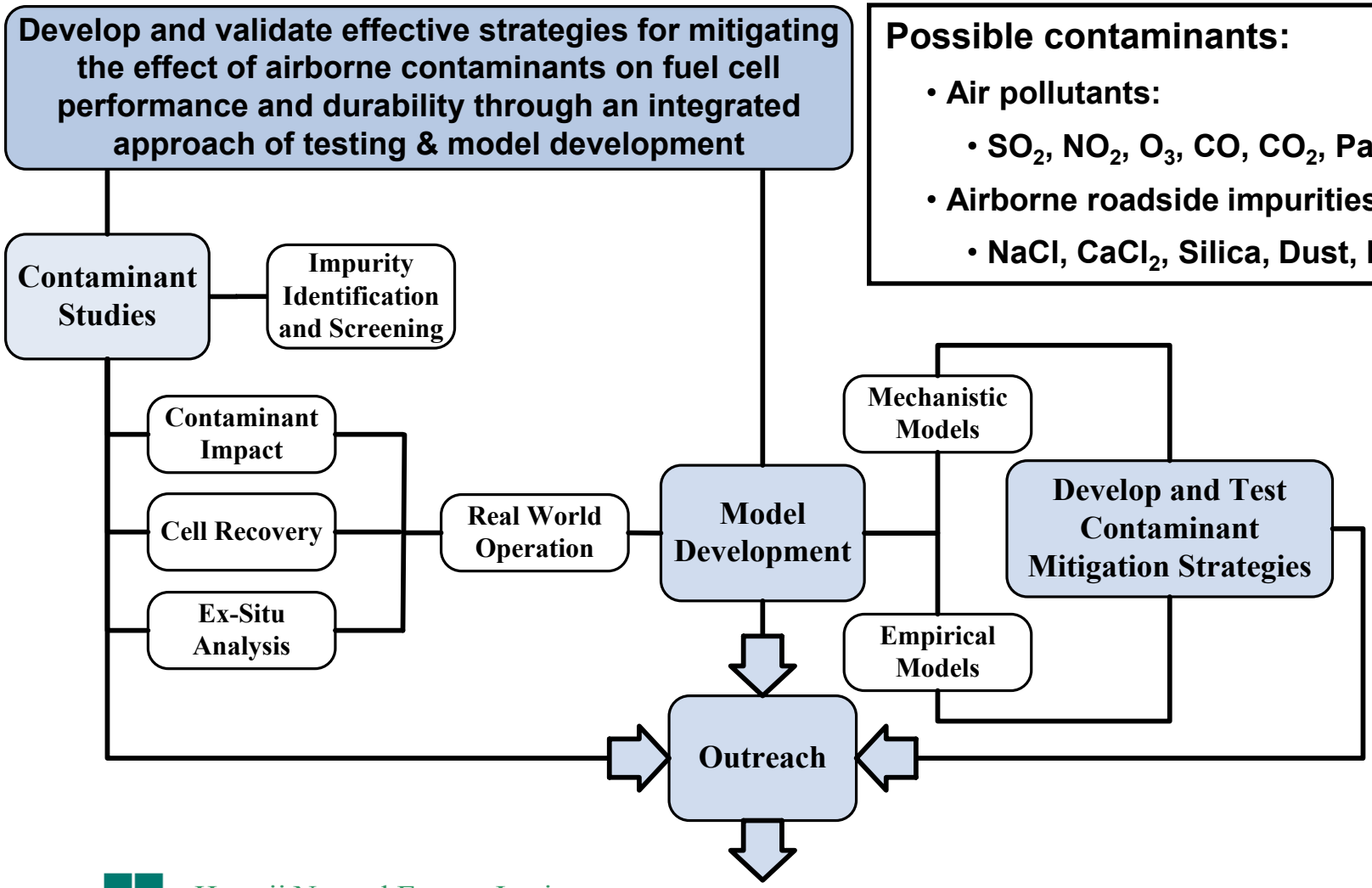
- 7 Fully-Automated Single Cell Fuel Cell Test Stations, Several Additional Systems in Place
- Multi-kW Test Capability for Full-Size Systems
- Real-Time GC and MS Capability for Continuous Feedstock and Effluent Analysis
- On-Site Scanning Electron Microscopy Facility and Access to UConn's Institute For Materials Science With Complete Materials Characterization Capability
- Prototype Component Fabrication Facility For Catalyst Formulation, Membrane Production, and MEA Fabrication
- Facilities for Numerical Analysis and Multi-Physics Modeling



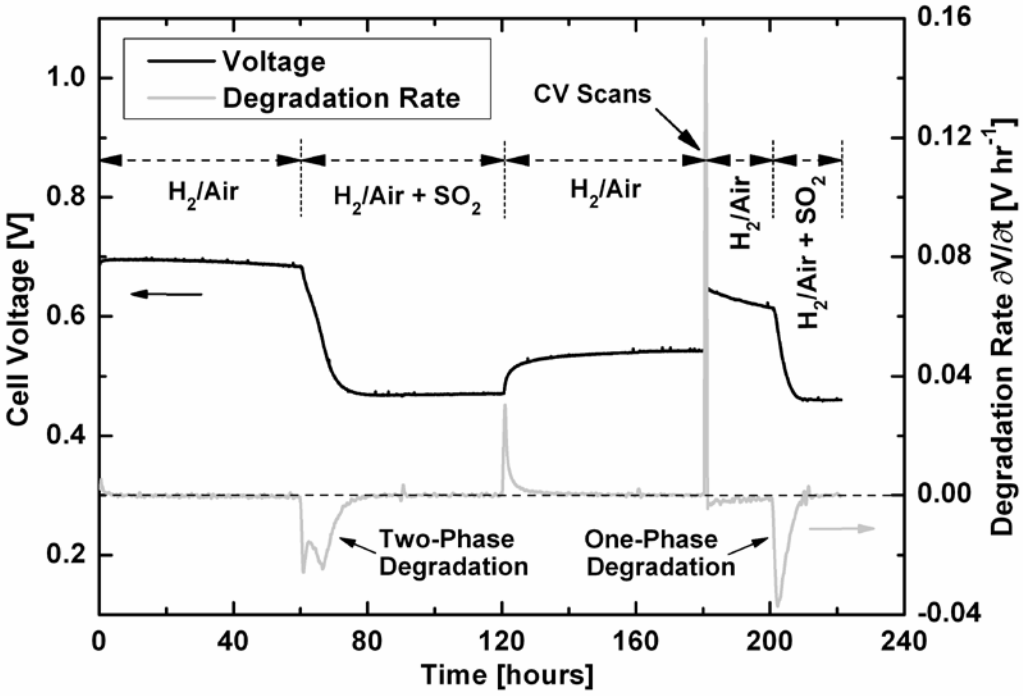




Approach


Develop and validate effective strategies for mitigating the effect of airborne contaminants on fuel cell performance and durability through an integrated approach of testing & model development
Possible contaminants:
• Air pollutants:
• SO_2, NO_2, O_3, CO, CO_2, Particulates
• Airborne roadside impurities:
• NaCl, $CaCl_2$, Silica, Dust, Particulates
Contaminant Studies
Impurity Identification and Screening
Contaminant Impact
Cell Recovery
Ex-Situ Analysis
Real World Operation
Model Development
Mechanistic Models
Empirical Models
Develop and Test Contaminant Mitigation Strategies
Outreach

Previous work (ONR funded) showing Dual Poisoning Mechanism for SO_2



- SO_2 is an important air contaminant for both performance and durability effects

- Two performance degradation phases observed during initial poisoning
- Self-induced recovery in neat H_2 & scrubbed air is incomplete
- Initial performance can be restored with multiple CV scans
- Accelerated degradation in neat H_2 & scrubbed air after initial poisoning and recovery
- Detailed analysis (e.g. cyclic voltammetry, segmented cells, gas chromatography & EIS) used to study poisoning processes
- Promising recovery techniques developed in collaboration with NRL/ONR

Task Timeline & Milestones

Task	Year 1	Year 2	Year 3	Year 4
1. Contaminant Studies				
2. Real Life Operation & Mitigation Strategies				
3. Modeling of Contaminant Effects				
4. Outreach				
• End of Fiscal Year Milestones	• Prioritize, test, & report performance impact of relevant airborne contaminants	• Report effects of real life operation on performance & durability	• Report principle poisoning mechanisms and spatial modeling results	• Demonstrate successful mitigation of most significant airborne contaminants

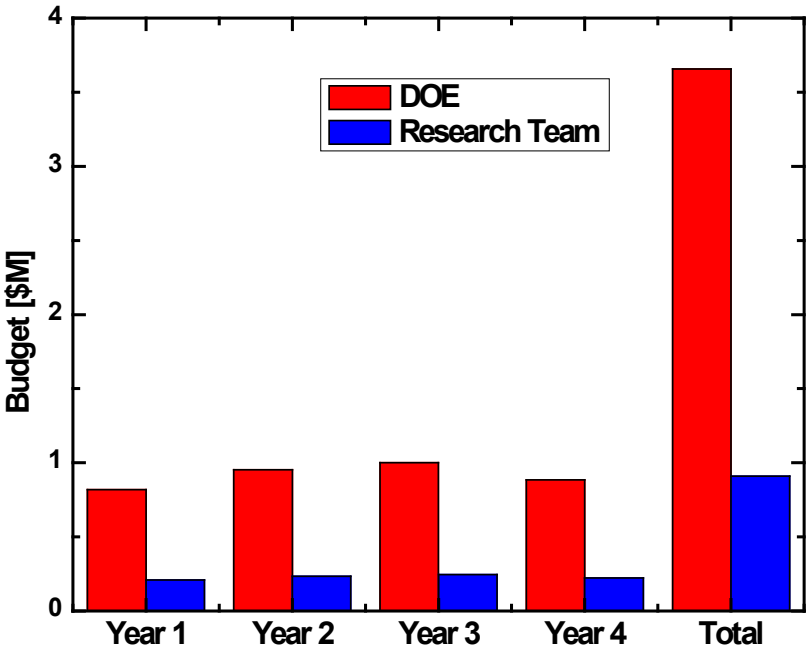
Go/No-Go Decisions After Year Two (All criteria must be satisfied)

No.	Success Criteria	YES	NO
1	Contaminant studies show significant impact on cell performance?	☐	☐
2	Modeling and experiments increase understanding of poisoning mechanisms and process?	☐	☐
3	Mitigations measures / techniques have been identified?	☐	☐

Partner Responsibilities

Task/Institution	HNEI	CGFCC	Ballard	UTC
Impurity Screening	X	X	X	X
Testing	X	X		
Analysis	X	X	X	X
Empirical Modeling	X	X		
Mechanistic Modeling		X		
Mitigation Strategy Development	X	X	X	X
Mitigation Strategy Testing	X	X		
Outreach	X	X	X	X

Yearly Budget & Current Annual Testing Hours



Additional inputs/needs:

- **DOE or lab lead coordination with goal of facilitating dissemination of information within program and communication of results for all awards given related to air impurities**

- **Estimated annual testing (hrs) for 2 dedicated test stations at each institution:**

Organization	Impurity Screening	Contaminant Impact/Recovery	Real World Operation & Mitigation Strategy Development	Total
HNEI	2000	12,500	2,500	17,000
CGFCC	2000	13,500	1,500	17,000

Summary

- **Research team with proven record assembled to test and model effects of airborne impurities on PEMFC performance and durability**
- **Understanding of contaminant behavior from testing will be used to develop effective mitigation strategies wherever feasible.**
- **HNEI & CGFCC will conduct testing and develop models and mitigation strategies for airborne contaminants**
- **Ballard Power Systems and UTC Power will provide input & feedback on impurity selection & development of modeling and mitigation methods**